# FIELD'S

## MINING ENGINEERS'

### REPORT BOOK

CHARLES GRIFFIN & C.º L.T.D

# MINING ENGINEERS' REPORT BOOK

AND

# DIRECTORS' AND SHAREHOLDERS' GUIDE

## TO MINING REPORTS

BY

## EDWIN R. FIELD

MEMBER OF
THE INSTITUTION OF MINING AND METALLURGY, LONDON;
THE AUSTRALASIAN INSTITUTE OF MINING ENGINEERS, ETC.
CONSULTING MINING ENGINEER, MELBOURNE, AUSTRALIA
CABLE ADDRESS (REUTER)—SEQUILHOS

*Third Edition, Revised and Enlarged*

LONDON

CHARLES GRIFFIN & CO., LIMITED

EXETER STREET, STRAND

1909

# NOTE TO THIRD EDITION

THE kindly welcome which this little book has met with has encouraged the issue of the third edition, in which much new matter has been added, and the tables extended, in order to make it more useful to directors and shareholders.

The sale of two editions has plainly shown that the Questions, which were compiled by the Author for use in his own practice, have been found of assistance to other mining engineers when reporting on mining propositions ; and it is hoped that the revised tables will add to the usefulness of the book in the field, when larger works are not available.

A new feature is the provision for cabling reports economically. The addition of heavy capital letters preceding the sections into which the Questions are divided facilitates reference to the larger divisions. The numbering of the Questions remains the same as in former editions.

Investors and Directors will find the Questions of assistance in investigating the value of mining properties, while the diagrams, etc., will help Directors and others who are not necessarily practical miners to a clearer understanding of mining reports. The application to mining investment of ordinary business principles, which seem to be specially neglected in that connection, would do much to remove a great reproach and source of failure from the industry.

# INDEX

**(The figures refer to the number of the question)**

# INDEX

# INDEX

## TABLES AND USEFUL DATA.

# CABLED REPORTS

In reporting by cable, the use of the following code sentences, in conjunction with this book, may considerably shorten cables. Cypher words must be arranged for the sentences. The name of the mine, if it is necessary to send it, will come next after the code word, and the letter referring to the heading, or the number of the question, will follow in the usual way. Any code in use between the parties will be used for the letters or numbers.

| Code Word. | Meaning. |
|---|---|
| ................... | In reporting on the................... mine, pay particular attention to heading..................... (or question number...... ........). |
| ................... | Report on........ ........mine only as to heading................... (or question................... ). |
| ................... | Referring to heading................... (or question................. ). |

# IN REPORTING ON ANY MINE:

GIVE THE FOLLOWING INFORMATION SO
FAR AS IT APPLIES AND IS OBTAIN-
ABLE :—

## A. Situation—

1. State shortly the geographical position of the mine.

2. What is the nearest port; what roads, railways, etc., are there to it?

## B. Area—

3. Give the area of the property or properties.

4. Who owns the surrounding ground? Give a list of companies operating in the neighbourhood.

*Note.*—Reports and documents not in the handwriting of the person signing, should be signed on each page.

# SYMBOL, HARDNESS, AND SPECIFIC GRAVITY OF DIFFERENT SUBSTANCES, WITH WEIGHT OF ONE CUBIC FOOT, IF PURE.

| Symbol. | Substance. | Hardness. | Specific Gravity. | Weight (lbs.). |
|---|---|---|---|---|
| $H_2O$ | Water . . . | .. | 1·0 | 62·5 |
|  | Coal . . . | 0·5-2·5 | 1·3 | 80* |
|  | Blue Gum . . | .. | 0·84 | 52 |
|  | Pine . . . | .. | 0·65 | 40 |
|  | Granite . . . | .. | 2·69 | 168* |
| $SiO_2$ | Quartz . . . | 7·0 | 2·64 | 165 |
| Al | Aluminium . . | .. | 2·7 | 169† |
| Sb | Antimony . . | 3·0-3·5 | 6·7 | 419 |
| As | Arsenic . . . | 3·5 | 5·76 | 360 |
|  | Chalk . . . | .. | 1·92 | 120* |
| Cu | Copper . . . | 2·5-3·0 | 8·79 | 550 |
| Au | Gold . . . | 2·5-3·0 | 19·26 | 1203 |
| Fe | Iron . . . | 4·5 | 7·7 | 481† |
| Pb | Lead . . . | .. | 11·4 | 710 |
| Mn | Manganese . . | .. | 8 | 500 |
| Hg | Mercury . . . | .. | 13·56 | 846 |
| Pt | Platinum . . | 4·0-4·5 | 21·5 | 1343 |
| Ag | Silver . . . | 2·5-3·0 | 10·7 | 655 |
| S | Sulphur . . . | .. | 2·0 | 125 |
| Sn | Tin . . . | .. | 7·4 | 460 |
| Zn | Zinc . . . | .. | 7·2 | 437 |
| $BaSO_4$ | Barytes . . . | 2·5-3·5 | 4·5 | 281 |
| Cu, Pb, Sb, and S | Bournonite . . | 2·5-3·0 | 5·8 | 362 |
| $CaCO_3$ | Calcite . . . | 3·0 | 2·6 | 170 |
| $CuFeS_2$ | Chalcopyrite, Copper Pyrites | 3·5-4·0 | 4·2 | 262 |
| PbS | Galena . . . | 2·5-3·0 | 7·5 | 469 |
| FeAsS | Mispickel. Arsenical Pyrites | 5·5-6·0 | 6·0 | 375 |
| $MnO_2$ | Pyrolusite . . | 2·0-5·5 | 4·9 | 306 |
| $FeS_2$ | Pyrite, Mundic . | 6·0-6·5 | 5·0 | 312 |
| $Sb_2S_3$ | Stibnite . . | 2·0 | 4·6 | 287 |
| ZnS | Zinc Blende . . | 3·5-4·0 | 4·0 | 250 |

\* Varies considerably.      † Wrought.

5. What is the angle of dip of the lode or ore deposit? Would it soon dip out of the lease when sunk on?

## C. Title to Mine, Machine-sites, etc.—

### A. *Lease from the Crown.*

6. Abstract of conditions.

7. How long to run.

8. Can it be renewed, and on what conditions and terms?

### B. *Lease from Private Parties.*

9. Lessor's title.

10. Particulars of proposed instrument of lease.

    *a.* How long to run.

    *b.* Can it be renewed, and on what conditions and terms?

## CORRUGATED GALVANISED IRON SHEETS.

| | Square feet per ton covered. | | Weight per square foot. |
|---|---|---|---|
| | Before fixing. | Including laps. | |
| 24 gauge . | 1900 | 1540 | 1 lb. 3 ozs. |
| 26　　,,　　. | 2250 | 1800 | 1 ,, 0 ,, |

### CONTENTS OF HALF-TON CASES (No. of sheets).

| 24 gauge. | Length, ft. | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|
| | Number. | 83 | 70 | 60 | 52 | 47 | 42 |

| 26 gauge. | Length, ft. | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|
| | Number. | 115 | 96 | 82 | 72 | 64 | 57 |

In fixing, lap about 6″ at ends, 3″ at sides.

### STEEL WIRE—LENGTH PER CWT.

| Gauge. | 6 | 8 | 10 |
|---|---|---|---|
| Yards. | 361 | 509 | 747 |

### LADDERS.

Sides, 4″×2″ hardwood.
Rungs, ¾″ round iron, 13½″ long.
Depth of holes in sides, 1¼″.
Width, 11″ in the clear, inside the sides.
Step, 11″ centre to centre.
Three bolts or rivets in each length of 11′ 11″ or 15′ 7″.
Put end rungs 5½″ from ends, so that the lengths give the right
　distance of step when joined.

### CONCRETE.

Take parts by volume. Mix twice dry and twice wet.

| | British Admiralty. | Victorian Government. |
|---|---|---|
| Stones 2½″ to 3″, broken, *not* round | 6 | 3 |
| Sharp sand (no slime) . . . | 3 | 2 |
| Portland cement . . . . | 1⅓ | 1 |

### GEARED OR PULLEY WHEELS.

To find the number of revolutions one will make to another,
divide the diameter of the driving wheel by the diameter of the
driven wheel,—or divide the number of teeth in the driving
wheel by the number of teeth in the driven wheel. The result
will be the number of revolutions the driven wheel will make to
one of the driving wheel.

    *c.* What provisions are made as to purchase, compensation, or removal of machinery or other improvements, at expiry or earlier determination of lease?

    *d.* Provisions as to sub-letting or assigning.

    *e.* Remaining conditions of importance.

  **C.** *Freehold.*

11. Description of deeds.

12. In whose name?

13. In whose possession?

14. Has a solicitor examined them and certified that they are in order?

15. Are they free from all incumbrances; if not, what are the incumbrances?

# HORSE-POWER OF ENGINES & BOILERS.

The old rules for nominal horse-power of boilers and engines are quite useless now that high pressures are employed.

The modern standard for boilers is lbs. of water evaporated per hour.

The horse-power of engines is calculated with reference to speed, pressure, etc., etc.

## ENGINES.

To find the indicated horse-power of an engine :—

A = Area of piston in sq. inches.
P = Average pressure in the cylinder in lbs. per sq. inch.
L = Length of stroke in feet.
N = Number of revolutions per minute.

Then $\dfrac{2PLAN}{33,000} = $ I.H.P.

*Note.*—If the engine is not of good design, or is not in good order, make a liberal deduction from this result, which is the *best* the engine should do under the given conditions.

Sq. inches in cylinder = diameter squared multiplied by ·7854.

P, average pressure in cylinder, is *considerably* less than the boiler gauge pressure—for rough work, say half.

The consumption of fuel and steam per horse-power hour varies with the class of engine employed, the pressure, point of cut-off, etc., etc.

The following table gives an approximation to the consumption of fuel per horse-power hour :—

| | | |
|---|---|---|
| High-speed engines . . | 3·5 to 4 | lbs. of coal. |
| Corliss single-cylinder non-condensing . . | 3·0 to 3·25 | ,, |
| Do. condensing . . | 2·5 to 2·62 | ,, |
| Do. compound condensing | 1·87 to 2·0 | ,, |

## D. General Conditions affecting Title.

16. *Mining Laws.*—Give a short sketch of the general nature of these.

*Note.*—It may be advisable to accompany your report with a copy of all laws and regulations affecting mining and mining companies.

17. Labour conditions.

18. Pumping conditions.

19. Any customs affecting the property, or any other disabilities whatever.

## E. Charges on Property.

20. Rent.

21. Rates $\frac{and}{or}$ taxes.

22. Royalty.

23. Any other charges.

## F. Supply of Labour.

24. Is this ample or otherwise and obtained locally or imported?

# HORSE-POWER OF ENGINES & BOILERS,
### *Continued.*

---

### STEAM.

1 cubic foot of steam at 50 lbs. gauge pressure = ·1516 lb.
      Do.          100 lbs.      ,,      = ·2628 lb.
      Do.          125 lbs.      ,,      = ·3162 lb.

---

Live steam may be allowed to flow through pipes at a speed of up to 8000 feet per minute. The speed of exhaust steam should not exceed 4000 feet per minute.

---

Condensing engines require 20 to 25 gallons of water to condense the steam evaporated from 1 gallon of water.

---

### BOILERS.

So much depends on the class of fuel, method of firing, and general conditions, that it is difficult to give definite rules in a small space.

The following particulars of a boiler constructed to evaporate 3000 lbs. of water per hour, with good wood fuel, are of interest for purposes of comparison :—

Cornish steel boiler, burning wood fuel.

    26 ft. × 6 ft. × 3 ft. 2 in. flue, shell $\frac{9}{16}$ in., flue $\frac{1}{2}$ in., ends $\frac{5}{8}$ in. Fire-bars, 2 lengths of 3 ft. each.

    Working pressure 150 lbs. Tested to 250 lbs. To evaporate 3000 lbs. of water per hour, or, at 30 lbs. per H.P. hour, 100 H.P.

    Weight of boiler $11\frac{1}{2}$ tons, mountings $2\frac{1}{2}$ tons (approx.).

    With coal instead of firewood, the evaporation would be a little higher.

In Lancashire boilers the furnaces are too small for wood fuel.

25. Give rates of wages in the past for skilled, unskilled, native, or other labour. Give present rates, and prospects for the future.

26. Have there been any strikes?

27. Are there any miners' unions, etc., and if so, how do they affect the working of the mine?

## G. Mining Timber and Fuel.

28. Present supply and future prospects.

29. Cost and quality.

## H. Mining Stores, etc.

30. Where and how obtainable?

31. Are costs reasonable? Give prices of a few important items.

32. Where is the nearest well-appointed foundry?

33. What facilities exist for repairs to machinery, etc.?

## SAFETY VALVES.



W = Weight of ball in lbs.
$x$ =   ,,       lever   ,,
$y$ =   ,,       valve   ,,
G = Distance in inches to centre of gravity of lever.
F =    ,,       ,,     fulcrum to centre of valve.
L =    ,,       ,,       ,,    to centre of ball.
D = Diameter of valve in inches.
A = Area of valve in sq. inches = $D^2 \times \cdot 7854$.
P = Pressure of steam in lbs. per sq. inch.

$$P = \frac{(W \times L) + (x \times G) + (y \times F)}{A \times F}.$$

Neglecting weight of valve and lever,

$$P = \frac{WL}{AF}, \qquad W = \frac{PAF}{L},$$

$$L = \frac{PAF}{W}, \qquad A = \frac{WL}{FP}.$$

---

## NOTES TO TABLE ON PAGE 12.

Doubling the diameter doubles the circumference.

Doubling the diameter increases the area, weight, and capacity four times.

Multiplying the diameter by three increases the area, weight, and capacity nine times.

Area of circle = diameter squared $\times \cdot 7854$.

Diameter of circle = circumference $\times \cdot 31831$.

Circumference of circle = diameter $\times 3 \cdot 1416$.

$3 \cdot 1416$ is usually represented by the symbol $\pi$.

## I. Travelling and Transport Facilities, etc.

34. Roads in the vicinity of the mine.

35. Right-of-way to the property.

36. Postal and telegraphic facilities.

37. Banks in district, offices, money exchange, charges on bullion, etc.

38. Mining courts and Wardens' offices, etc.

## J. Public Mills or Metallurgical Works.

39. Are there any in the district; if so, where?

40. What are the costs of carriage from the mine?

41. Are such mills, etc., well equipped?

42. What are their charges?

## AREAS AND CIRCUMFERENCES OF CYLINDERS, WITH GALLONS AND WEIGHTS OF WATER CONTAINED IN PIPES ONE FOOT LONG.

| Diam. in inches. | Area in square inches. | Gallons. | Weight in lbs. | Circum-ference. |
|---|---|---|---|---|
| 1 | ·7854 | ·034 | ·34 | 3·1416 |
| 2 | 3·1416 | ·136 | 1·36 | 6·2832 |
| 3 | 7·0686 | ·306 | 3·06 | 9·4248 |
| 4 | 12·5664 | ·544 | 5·44 | 12·5664 |
| 5 | 19·6350 | ·848 | 8·48 | 15·7080 |
| 6 | 28·2744 | 1·224 | 12·24 | 18·8496 |
| 7 | 38·4846 | 1·622 | 16·22 | 21·9912 |
| 8 | 50·2656 | 2·176 | 21·76 | 25·1328 |
| 9 | 63·6174 | 2·754 | 27·54 | 28·2744 |
| 10 | 78·5400 | 3·392 | 33·92 | 31·4160 |
| 11 | 95·0334 | 4·105 | 41·05 | 34·5576 |
| 12 | 113·0976 | 4·896 | 48·96 | 37·6992 |
| 13 | 132·7326 | 5·734 | 57·34 | 40·8408 |
| 14 | 153·9384 | 6·648 | 66·48 | 43·9824 |
| 15 | 176·7150 | 7·632 | 76·32 | 47·1240 |
| 16 | 201·0624 | 8·704 | 87·04 | 50·2656 |
| 17 | 226·9806 | 9·805 | 98·05 | 53·4072 |
| 18 | 254·4696 | 11·016 | 110·16 | 56·5488 |
| 20 | 314·1600 | 13·568 | 135·68 | 62·8320 |
| 24 | 452·3904 | 19·584 | 195·84 | 75·3984 |

See notes on page 10.

# K. Other Mines in the Locality.

43. Are any of them worked deeper than this property?

44. Are there any accumulations of gas, water, etc., which might endanger this property or increase the costs of working?

45. Can you give any other information about other mines which might be of value in connection with this property? *E.g.*, Can ore be obtained on favourable terms to treat with ore from this mine, or otherwise?

# L. History of the Mine—

*Note.*—Official reports and returns, duly certified, should be obtained wherever possible. State from what sources other information is obtained.

46. Have you any reports on the mine or district by other persons?

## PUMPING NOTES.

To find approximately the pressure of water in pipes, divide the height in feet by two, which gives the pressure in lbs. per sq. inch at the bottom.

For accurate calculations multiply the height in feet by ·434 for the pressure; and for the height in feet multiply the pressure in lbs. per sq. inch by 2·3.

The fluid friction in pipes increases in the proportion of the square of the velocity.

Bends, angles, etc., in pipes, especially if sharp, increase the friction very greatly.

The speed of water in pump pipes should not exceed 250 feet per minute, and a lower velocity is to be preferred.

Work pumps with few strokes per minute on a long stroke, rather than with a greater number on a short stroke.

Change position of bucket or plunger in working barrel occasionally, if working on short stroke.

1 pint of water weighs 1¼ lb.

1 gallon of water weighs 10 lbs.

1      ,,      =277¼ cubic inches.

1 cubic foot of water weighs 62·5 lbs.=6·25 gallons.

To find the horse-power necessary to pump water to a given height, multiply the number of gallons to be raised per minute by 10 (which gives the weight in lbs.) and by the height in feet, and divide the product by 33,000.

To allow for friction and loss on theoretical efficiency, the result should be doubled to provide a safe I.H.P.

Let $g$=gallons to be raised per minute.
$f$=height in feet water is to be raised.

Then $\dfrac{10g \times f \times 2}{33,000}$=I.H.P.

If so, send them, and give your comments on them and their authors.

47. When was the mine first discovered, and worked, and by whom?

48. If unworked or abandoned at any time, state when and by whom. Are any satisfactory reasons obtainable?

49. Is the mine being worked now; if so, to what extent?

50. Will reliable returns be forwarded regularly; if so, by whom?

51. *Past Yields.*—Give the number of tons treated, ounces of bullion obtained, value of bullion per ounce, value per ton. In the case of mineral mines, give analyses of the ores, value and contents of matte or bullion, etc.

*To Calculate the Quantity of Water thrown by Pumps.*—From the Table on page 12, the contents, in gallons, of 1 foot of the pipe selected can be ascertained. This multiplied by 250, or such less speed as may be decided on, gives the (theoretical) number of gallons the pipe will deliver per minute when supplied by a double-acting pump.

In the case of a single-acting pump, since the water is at rest during one stroke, only half the quantity so found can be dealt with per minute.

With a first-class pump at least 30 per cent. should be deducted from these results for slip, etc., while a much higher allowance must be made for pumps of inferior efficiency.

Though direct-acting pumps can be run at speeds of 200 to 250 feet per minute, an ordinary Cornish pump will not travel at these speeds ; 120 feet per minute, intermittently, being as fast as is generally attempted.

The following examples give simple calculations for direct-acting and Cornish pumps :—

*Example* 1—*Direct-Acting Pumps.*—A 10-inch pipe, 1 foot long, contains 3·39 gallons. Multiplied by 200, the speed in feet per minute = 678. Less (say) 40 per cent. for slip, etc. = 407 gallons per minute thrown by a double-action pump of good design.

Single-action pumps under the same conditions would throw 203 gallons per minute.

*Example* 2—*Cornish Pumps.*—A 10-inch pump, working on a 5-feet stroke, at the rate of 12 strokes per minute = 60 feet of water per minute, travelling intermittently at the rate of 120 feet per minute.

One foot of a 10-inch pipe contains 3·39 gallons : multiply by 60 = 203 gallons per minute. Deduct 40 per cent. for slip, etc. = 122 gallons, or 7320 gallons per hour, and 175,680 gallons per day of 24 hours.

52. How is the ore treated; when and where is it treated?

53. Have you seen any books or records confirming the returns, etc.; if so, are they reliable and satisfactory?

54. Has the past management been good; has sufficient capital been available; have any cross-cuts been driven, or other exploring work done?

55. Give any other information of interest in the history of the mine.

**M. Description of the Mine—**

56. What are the geological features and formations of the district, especially near the mines?

57. What is the nature of the vein stuff, and what minerals does it contain? Is the gold fine or coarse?

## SUNDRY MEASURES, Etc.

Metre = 3·28 feet = 39·37 inches.
Kilometre = 1093·6 yards.
Centimetre = ·3937 inch.
Millimetre = ·03937 inch.
1 foot = ·3048 metre.
1 square metre = 10·76 square feet.
Hectare = 2·47 acres.
1 cubic metre = 220 gallons.
Stere = 1·31 cubic yards.

Litre = 1·76 pints = ·22 gallon.
1 gallon = 4·543 litres.
Gramme = 15·43 grains troy.
Kilogramme = 2·2 lbs. avoird.
1000 kilogrammes = 1 metric ton = 2204·58 lbs. avoird.
1 oz. avoirdupois = 28·35 grammes = ·911458 oz, troy.
1 oz. troy = 31·103 grammes = 1·09714 oz. avoird.

### TEMPERATURE CONVERSION.

Temp. Fahrenheit = $\frac{9}{5}$ (Temp. Centigrade) + 32°.
Temp. Centigrade = $\frac{5}{9}$ (Temp. Fahrenheit − 32°).
Temp. Fahrenheit = $\frac{9}{4}$ (Temp. Réaumur) + 32°.
Temp. Réaumur = $\frac{4}{9}$ (Temp. Fahrenheit − 32°).

3 new bronze pennies weigh 1 oz. avoird.
A bronze halfpenny is 1 inch in diameter exactly.
A bronze penny is $\frac{1}{16}$th of an inch thick exactly.

Sound travels through air at about 1120 ft. per second.
Light travels 186,000 miles per second.

58. Describe the locality, and give any photographs you can obtain of the property, with full descriptions and dates taken.

59. Describe the reefs or lodes.

60. Is the gold distributed through the stone and all across the lode regularly, or does it occur on one wall or in shoots or patches?

61. Is the mine on level country; what is its elevation above sea-level, and above any streams, etc., near it?

62. Is the surface naturally well-drained?

63. Is there any limestone or other formation near, likely to be specially pervious to water?

64. What is the natural water level?

65. What are the dip and strike of *strata* and *reefs*?

# WEIGHTS AND MEASURES.

## AVOIRDUPOIS.

| | | |
|---|---|---|
| 16 drachms | = 1 oz. | |
| 16 ozs. .. | = 1 lb. | |
| 28 lbs... .. | = 1 qr. | |
| 112 lbs. or | } = 1 cwt. | |
| 4 qrs. | | |
| 20 cwts. .. | = 1 ton. | |

## TROY.

| | | |
|---|---|---|
| 24 grains .. | = 1 dwt. |
| 20 dwts. .. | = 1 oz. |
| 12 ozs. .. .. | = 1 lb. |

*Note.*—The grain is the same in both cases.

| | | |
|---|---|---|
| 7000 grains .. .. | = | 1 lb. avoirdupois. |
| 5760 „ .. .. | = | 1 lb. troy. |
| 175 lbs troy .. .. | = 144 lbs. avoirdupois. |
| 1 ton of gold .. .. | = 32,666 ozs. troy. |

## LENGTH.

| | |
|---|---|
| 12 lines .. | = 1 in. |
| 12 ins. .. | = 1 ft. |
| 16½ ft. .. | = 1 pole. |
| 220 yds. .. | = 1 furlong. |
| 8 furlongs | = 1 mile. |

| | |
|---|---|
| 6 ft. .. | = 1 fathom. |
| 1760 yds. .. | = 1 mile. |
| 7·92 ins. | = 1 link. |
| 100 links | } = 1 chain. |
| 66 ft. | |
| 80 chains | = 1 mile. |

## SQUARE.

| | |
|---|---|
| 144 sq. ins. | = 1 sq. ft. |
| 9 sq. ft. | = 1 sq. yd. |
| 4,840 sq. yds. | |
| 10 sq. chains | } = 1 acre. |
| 100,000 sq. links | |

| | |
|---|---|
| 272¼ sq. ft. | = 1 sq.rod or pole. |
| 40 rods | = 1 rood. |
| 4 roods | = 1 acre. |
| 640 acres | = 1 sq. mile. |
| 36 sq. ft. | = 1 sq. fathom. |

## CUBIC.

| | |
|---|---|
| 1728 cub. ins. | = 1 cub. ft. |
| 27 cub. ft. | = 1 cub. yd. |

| | |
|---|---|
| 128 c. ft. | = 1 cord of firewood. |
| 1 cord | = 2¼ tons. |

## LIQUID.

| | |
|---|---|
| 4 gills .. .. | = 1 pint. |
| 2 pints .. | = 1 quart. |
| 4 quarts .. | = 1 gallon. |
| 20 fluid ozs... | = 1 pint. |

| | |
|---|---|
| 54 gallons | = 1 hogshead. |
| 36 „ | = 1 barrel. |
| 27 „ | = 1 half hogshead. |
| 18 „ | = 1 kilderkin. |
| 12 „ | = 1 firkin. |

## MISCELLANEOUS.

PAPER.

| | |
|---|---|
| 24 sheets .. .. | = 1 quire. |
| 20 quires .. .. | = 1 ream. |

WHEAT, ETC.

| | |
|---|---|
| Bushel of wheat | = 60 lbs. |
| „ maize | = 56 lbs. |

66. Are any slides, faults, etc., known ?

67. Is the ground easily worked, or treacherous; what timbering is required ?

68. What quantity of water has to be pumped ?

69. Is it likely to increase as the mine is more opened up ?

70. Does the water interfere much with working the mine ?

71. Does the wet season make any difference to the quantity of water ?

72. Does the water contain anything likely to quickly corrode or choke the pumps ?

## N. Saving Appliances and Methods of Treatment—

73. Are these of approved pattern, etc. ? Give your opinion respecting them.

### PERCENTAGES CALCULATED TO TONS AND CWTS.

| Per cent. | Per Ton (Cwt.) | Per Ton (Lbs.) | Per Cwt. (Lbs.) |
|---|---|---|---|
| 1 | | 22·4 | 1·12 |
| 2 | | 44·8 | 2·24 |
| 3 | | 67·2 | 3·36 |
| 4 | | 89·6 | 4·48 |
| 5 | 1 | — | 5·60 |
| 6 | 1 | 22·4 | 6·72 |
| 7 | 1 | 44·8 | 7·84 |
| 8 | 1 | 67·2 | 8·96 |
| 9 | 1 | 89·6 | 10·08 |
| 10 | 2 | — | 11·20 |
| 11 | 2 | 22·4 | 12·32 |
| 12 | 2 | 44·8 | 13·44 |
| 13 | 2 | 67·2 | 14·56 |
| 14 | 2 | 89·6 | 15·68 |
| 15 | 3 | — | 16·80 |
| 16 | 3 | 22·4 | 17·92 |
| 17 | 3 | 44·8 | 19·04 |
| 18 | 3 | 67·2 | 20·16 |
| 19 | 3 | 89·6 | 21·28 |
| 20 | 4 | — | 22·40 |
| 21 | 4 | 22·4 | 23·52 |
| 22 | 4 | 44·8 | 24·64 |
| 23 | 4 | 67·2 | 25·76 |
| 24 | 4 | 89·6 | 26·88 |
| 25 | 5 | — | 28·00 |

### PERCENTAGES CALCULATED TO TONS AND CWTS.

| Per cent. | Per Ton (Cwt.) | Per Ton (Lbs.) | Per Cwt. (Lbs.) |
|---|---|---|---|
| 26 | 5 | 22·4 | 29·12 |
| 27 | 5 | 44·8 | 30·24 |
| 28 | 5 | 67·2 | 31·36 |
| 29 | 5 | 89·6 | 32·48 |
| 30 | 6 | — | 33·60 |
| 31 | 6 | 22·4 | 34·72 |
| 32 | 6 | 44·8 | 35·84 |
| 33 | 6 | 67·2 | 36·96 |
| 34 | 6 | 89·6 | 38·08 |
| 35 | 7 | — | 39·20 |
| 36 | 7 | 22·4 | 40·32 |
| 37 | 7 | 44·8 | 41·44 |
| 38 | 7 | 67·2 | 42·56 |
| 39 | 7 | 89·6 | 43·68 |
| 40 | 8 | — | 44·80 |
| 41 | 8 | 22·4 | 45·92 |
| 42 | 8 | 44·8 | 47·04 |
| 43 | 8 | 67·2 | 48·16 |
| 44 | 8 | 89·6 | 49·28 |
| 45 | 9 | — | 50·40 |
| 46 | 9 | 22·4 | 51·52 |
| 47 | 9 | 44·8 | 52·64 |
| 48 | 9 | 67·2 | 53·76 |
| 49 | 9 | 89·6 | 54·88 |
| 50 | 10 | — | 56·00 |

74. Is the ore easy to treat or crush?

75. Is it refractory or free milling?

## O. Concentrates and Tailings—

76. Have any been treated?

77. What quantities; how, when, and with what results?

78. If any on hand, state quantity and quality, also how, in your opinion, they should be treated.

## P. Assays or Trial Lots—

79. Where and by whom were these obtained, and on whose account?

80. By whom assayed or treated, and with what results?

## Q. Samples and Specimens—

81. Give exact descriptions (with reference to plans) of how and

## MOHS' SCALE OF HARDNESS.

1. Talc.  4. Fluor spar.  7. Quartz.
2. Rock salt.  5. Apatite.  8. Topaz.
3. Calc spar.  6. Felspar.  9. Sapphire.
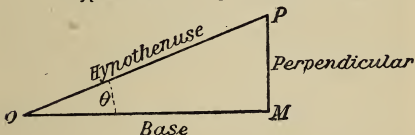10. Diamond.

## VON KOBELL'S SCALE OF FUSIBILITY.

1. Antimony glance (Antimonite)—Fuses in the candle flame.

2. Natrolite or Mesotype—May be rounded in the candle flame when in fine splinters.

3. Almandine-garnet—Fuses in large pieces before the blowpipe.

4. Actinolite (a variety of hornblende)—Fusible only in small fragments before the blowpipe.

5. Orthoclase (potash-felspar)—Fuses with difficulty.

6. Bronzite—Very refractory, fusing before the blowpipe only when in extremely minute splinters.

## TRIGONOMETRICAL RATIOS.

Base = Cosine $\theta \times$ Hyp. = Cot $\theta \times$ Perp.
Perp. = Sine $\theta \times$ Hyp. = Tan $\theta \times$ Base.
Hyp. = Cosec $\theta \times$ Perp. = Secant $\theta \times$ Base.



$$\text{Sine } \theta = \frac{\text{M.P.}}{\text{O.P.}} \qquad \text{Cosec } \theta = \frac{\text{O.P.}}{\text{M.P.}}$$

$$\text{Cosine } \theta = \frac{\text{O.M.}}{\text{O.P.}} \qquad \text{Secant } \theta = \frac{\text{O.P.}}{\text{O.M.}}$$

$$\text{Tan } \theta = \frac{\text{M.P.}}{\text{O.M.}} \qquad \text{Cotan } \theta = \frac{\text{O.M.}}{\text{M.P.}}$$

Sine 90°, Tan 45°, Chord 60°, each = 1.

where all samples were obtained, and by whom taken in each case.

82. Whose custody have they been in since they were taken?

83. Have strict precautions been taken at all times to prevent them being tampered with?

## R. Machinery, Furnaces, etc.—

*Note.*—Give diameter and stroke of cylinders, measurements of boilers, size of vats, etc. in any chlorination or cyanide plants, internal dimensions of furnaces, etc., and state whether they are of old or new type, and the condition all are in.

84. Describe all machinery, electric lighting plant, etc.

85. Describe all pumps; state whether they are of suitable type, and whether amply sufficient or not.

# WEIGHT OF IRON PER FOOT RUN, IN LBS.

## FLAT IRON.

| Breadth (inches). | Thickness (inches). | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{3}{8}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{7}{8}$ | 1 |
| 1 | ·21 | ·63 | ·83 | 1·25 | 1·67 | 2·08 | 2·92 | 3·33 |
| $1\frac{1}{2}$ | ·31 | ·94 | 1·25 | 1·88 | 2·50 | 3·13 | 4·38 | 5·00 |
| 2 | ·42 | 1·25 | 1·67 | 2·50 | 3·33 | 4·17 | 5·83 | 6·67 |
| 3 | ·63 | 1·88 | 2·50 | 3·75 | 5·00 | 6·25 | 8·75 | 10·00 |
| 6 | 1·25 | 3·75 | 5·00 | 7·50 | 10·00 | 12·50 | 17·50 | 20·00 |
| 12 | 2·50 | 7·50 | 10·00 | 15·00 | 20·00 | 25·00 | 35·00 | 40·00 |

Doubling the breadth while the thickness remains the same, or doubling the thickness while the breadth remains the same, doubles the weight.

## LEGAL STANDARD WIRE GAUGE.

| Number in Birmingham W. G. | Inches. | | Number in Birmingham W. G. | Inches. | |
|---|---|---|---|---|---|
| | Nearest 64th. | Decimals. | | Nearest 64th. | Decimals. |
| 7/0 | $\frac{1}{2}$ | ·500 | 7 | $\frac{11}{64}$ | ·176 |
| 0 | $\frac{21}{64}$ | ·324 | 8 | $\frac{5}{32}$ | ·160 |
| 1 | $\frac{19}{64}$ | ·300 | 9 | $\frac{9}{64}$ | ·144 |
| 2 | $\frac{9}{32}$ | ·276 | 10 | $\frac{1}{8}$ | ·128 |
| 3 | $\frac{1}{4}$ | ·252 | 12 | $\frac{7}{64}$ | ·104 |
| 4 | $\frac{15}{64}$ | ·232 | 15 | $\frac{5}{64}$ | ·072 |
| 5 | $\frac{3}{32}$ | ·212 | 20 | $\frac{1}{32}$ | ·036 |
| 6 | $\frac{1}{16}$ | ·192 | | | |

86. Describe all furnaces, flues, and any other appliances.

87. If water power is used, describe races, water-wheels, supply, etc.

88. Does it vary with the seasons?

89. What does it cost?

90. Describe any other improvements, buildings, offices, etc.

## S. Water Supply—

91. Is there an ample supply for boilers and works?

92. Is it of good quality?

93. Are there any facilities for conserving water, if necessary?

94. Would the expense of providing such be heavy?

95. Are strata suited for retaining water?

96. Is clay available?

# WEIGHT OF IRON PER FOOT RUN, IN LBS.

## ROUND AND SQUARE IRON.

| Diameter (inches). | Round (lbs.). | Square (lbs.). |
|:---:|:---:|:---:|
| $\frac{1}{4}$ | ·164 | ·208 |
| $\frac{5}{16}$ | ·256 | ·326 |
| $\frac{3}{8}$ | ·368 | ·469 |
| $\frac{7}{16}$ | ·501 | ·638 |
| $\frac{1}{2}$ | ·654 | ·833 |
| $\frac{9}{16}$ | ·828 | 1·055 |
| $\frac{5}{8}$ | 1·023 | 1·302 |
| $\frac{3}{4}$ | 1·473 | 1·875 |
| $\frac{7}{8}$ | 2·004 | 2·552 |
| 1 | 2·618 | 3·333 |

Doubling the diameter increases the weight four times.
Octagon steel weighs about the same as square iron.

## CAST IRON BALLS.

| Diameter (inches). | Weight (lbs.). | Diameter (inches). | Weight (lbs.). |
|:---:|:---:|:---:|:---:|
| 1 | ·14 | 5 | 17·21 |
| $1\frac{1}{2}$ | ·47 | 7 | 47·23 |
| 2 | 1·10 | 9 | 100·39 |
| 3 | 3·72 | 11 | 183·28 |
| 4 | 8·81 | 12 | 237·94 |

Weight in lbs. = diameter in inches cubed × ·1377.
Doubling the diameter increases the weight eight times.

97. Is there any trouble about polluting water-courses, etc., with tailings or chemical refuse from the works?

## T. Ground for Spoil Heaps, Machinery, etc., etc.—

98. Is there ample room for mullock heaps, machine and tramway sites, dams, tailings-pits, etc.?

99. Can they be conveniently located near the shafts, etc.?

## U. Plans—

State by whom plans and surveys have been made, and whether they appear to be reliable.

100. Give map of district, if procurable; if not, give rough sketch.

101. Give surface sketch showing

## MEMORANDA.

### CONTENTS OF REEFS.

14 cubic feet of *Quartz*, solid  = 1 ton.

21    "    "    broken = 1 ton.

A quartz reef 4·6 inches wide = 1 ton per square fathom.

A quartz reef 12 inches wide = 2½ tons per square fathom (approx.).

### BRICKS.

1 cubic yard of clay makes 450 bricks.

306 cubic feet = 1 rod of brickwork = 4350 bricks.

1 rod of brickwork requires about 1½ cubic yards of lime and 3 cubic yards of sand, and weighs about 15 tons.

### PAINTING.

Allow an average of about ¼ lb. to ⅓ lb. of paint per square yard for a first coat, and about ⅙ lb. for subsequent coats.

A fair mixture is 28 lbs. white lead, 2 pints turpentine, 6 pints linseed oil, 1 lb. litharge.

To find the side of a square equal in area to a given circle, multiply the diameter by ·8862.

Conversely, to find the diameter of a circle equal to a given square, multiply the side of the square by 1·1283.

position of shafts, buildings, roads, tramways, and machinery, giving approximate heights, etc.

102. Give plans of underground workings, showing shafts, tunnels, faces open, ground worked out, winzes, etc. Show old workings approximately, if no reliable plans obtainable.

# V. Underground Workings—

## (a) Past.

103. Have they been well carried out and are they open and accessible?

104. What condition is the timbering in?

105. Are the old workings completely worked out, or are there any available blocks worth working?

106. Should any portions be re-

# TABLE SHOWING DEGREES OF UNDER-LIE, LENGTH OF DIAGONAL, ETC., ETC.

(See Table, pages 36 and 38, and diagram, page 34.)

———

This gives at a glance the angle of underlie *from the horizontal*, when the distance the lode departs from the vertical, per foot sunk, is known.

It also gives the number of feet *on the underlie* between two levels—or the depth a vertical shaft must be sunk to give a certain number of feet of backs.

The Table can be used for length of rafters, etc., in buildings; sloping tramways and roadways, etc., and as an ordinary traverse table, as far as it goes.

Though the table is small, it may be used for large distances by multiplying the horizontal, vertical, and resulting distances *all* by the same figure.

———

*Example.*—A reef dips at the rate of 5 feet in every 10 feet of vertical depth.

In the column headed 5, and opposite 10 in the column of vertical distances, will be found 63° 27′, the angle of underlie, and 11·18 feet, the depth of an underlie shaft on the reef, or the number of feet of backs given by a straight shaft 10 feet deep.

This can be multiplied by 10 to give the backs yielded by a shaft 100 feet deep with the same angle of underlie, which, in the case cited, would be 111·8 feet.

Conversely, the relative distances in feet can be obtained when the angle of dip is known.

paired either for future working or
as air-ways?

(b) *Present workings:—ore in sight.*

107. State condition and appear-
ance of all faces.

108. Give quantity and quality
of all stone in sight and on the
surface.

109. State how situated with re-
ference to present shafts, levels,
machinery, etc.

110. Give the—

Greatest width of reef or lode.
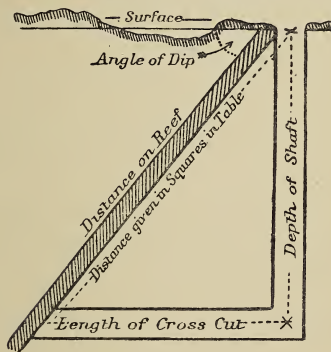Least      „       „
Average    „       „

If possible, verify this by measurements
of worked ground, stating number of cubic
feet allowed per ton.

# W. Future Workings—

111. What operations should, in

## DIAGRAM ILLUSTRATING TABLE ON PAGE 36.



### EXPLANATION.

| | |
|---|---|
| Angle of Dip | Given in degrees and minutes in table. |
| Depth of Shaft | = Vertical distances in left - hand column. |
| Length of Cross Cut | = Horizontal distances in top horizontal column. |
| Height of rise on reef | = Figures under degrees in table. |

*For method of using table, see examples on page 32.*

### ANGULAR MEASURE.

| | | | |
|---|---|---|---|
| 60 seconds (″) | .. | .. | = 1 minute. |
| 60 minutes (′) | .. | .. | = 1 degree. |
| 360 degrees (°) | .. | .. | = 1 circle. |

your opinion, be undertaken? and state generally how the property should be worked.

112. What additions and repairs to machinery, furnaces, plant, etc., are necessary or advisable?

113. What prospecting work (if any) do you recommend? Give your reasons.

## X. Estimates—

114. What time and cost would your proposals involve, and what profits can reasonably be expected per ton and per annum?

115. What time will elapse before returns should commence, making fair allowances for contingencies?

116. At what cost do you estimate the various parts of the works.

## TABLE SHOWING DEGREES OF UNDERLIE, ETC.

### Horizontal Distance.

| Vertical Distance. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 45° 0′ 1·414 | 26° 34′ 2·236 | 18° 26′ 3·162 | 14° 3′ 4·123 | 11° 19′ 5·099 | 9° 28′ 6·082 | 8° 8′ 7·071 | 7° 8′ 8·062 | 6° 21′ 9·055 | 5° 43′ 10·049 |
| 2 | 63° 27′ 2·236 | 45° 0′ 2·828 | 33° 41′ 3·605 | 26° 34′ 4·472 | 21° 49′ 5·385 | 18° 26′ 6·324 | 15° 57′ 7·280 | 14° 3′ 8·246 | 12° 31′ 9·219 | 11° 19′ 10·198 |
| 3 | 71° 34′ 3·162 | 56° 19′ 3·605 | 45° 0′ 4·242 | 36° 53′ 5·000 | 31° 0′ 5·831 | 26° 34′ 6·708 | 23° 12′ 7·615 | 20° 34′ 8·544 | 18° 26′ 9·486 | 16° 42′ 10·440 |
| 4 | 75° 58′ 4·123 | 63° 27′ 4·472 | 53° 8′ 5·000 | 45° 0′ 5·656 | 38° 40′ 6·403 | 33° 41′ 7·211 | 29° 45′ 8·062 | 26° 34′ 8·944 | 23° 58′ 9·848 | 21° 49′ 10·770 |
| 5 | 78° 42′ 5·099 | 68° 12′ 5·385 | 59° 2′ 5·831 | 51° 21′ 6·403 | 45° 0′ 7·071 | 39° 48′ 7·810 | 35° 32′ 8·602 | 32° 1′ 9·434 | 29° 3′ 10·295 | 26° 34′ 11·180 |
| 6 | 80° 33′ 6·082 | 71° 34′ 6·324 | 63° 27′ 6·708 | 56° 19′ 7·211 | 50° 12′ 7·810 | 45° 0′ 8·485 | 40° 36′ 9·219 | 36° 53′ 10·000 | 33° 41′ 10·816 | 30° 58′ 11·661 |
| 7 | 81° 53′ 7·071 | 74° 4′ 7·280 | 66° 48′ 7·615 | 60° 16′ 8·062 | 54° 28′ 8·602 | 49° 24′ 9·219 | 45° 0′ 9·899 | 41° 12′ 10·630 | 37° 52′ 11·401 | 35° 0′ 12·206 |
| 8 | 82° 53′ 8·062 | 75° 58′ 8·246 | 69° 26′ 8·544 | 63° 27′ 8·944 | 58° 0′ 9·434 | 53° 8′ 10·000 | 48° 49′ 10·630 | 45° 0′ 11·313 | 41° 38′ 12·041 | 38° 40′ 12·806 |
| 9 | 83° 40′ 9·055 | 77° 29′ 9·219 | 71° 34′ 9·486 | 66° 3′ 9·848 | 60° 57′ 10·295 | 56° 19′ 10·816 | 52° 7′ 11·401 | 48° 22′ 12·041 | 45° 0′ 12·727 | 42° 0′ 13·453 |
| 10 | 84° 18′ 10·049 | 78° 42′ 10·198 | 73° 18′ 10·440 | 68° 12′ 10·770 | 63° 27′ 11·180 | 59° 2′ 11·661 | 55° 0′ 12·206 | 51° 21′ 12·806 | 48° 1′ 13·453 | 45° 0′ 14·142 |

such as mining, treating, etc.? Go fully into this point.

117. What should the output be, when in full work?

118. What quantity will present or proposed appliances treat?

119. What do you estimate the life of the mine at, and what are your reasons for thinking so?

120. What do you estimate the cost of any other important work to be?

121. What working capital is recommended? Is this ample, and does it allow for future requirements and contingencies?

## Y. Purchase, etc.—

122. What are the owner's reasons for wishing to dispose of the property?

## TABLE SHOWING DEGREES OF UNDERLIE, ETC.

Horizontal Distance.

| Vertical Distance. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 84°49' 11·045 | 79°42' 11·180 | 74°45' 11·401 | 70°2' 11·704 | 65°34' 12·083 | 61°23' 12·530 | 57°32' 13·038 | 53°59' 13·601 | 50°43' 14·177 | 47°44' 14·866 |
| 12 | 85°15' 12·041 | 80°33' 12·165 | 75°58' 12·530 | 71°34' 12·569 | 67°23' 13·000 | 62°27' 13·892 | 59°45' 14·764 | 56°19' 14·422 | 53°8' 15·000 | 50°12' 15·620 |
| 13 | 85°37' 13·038 | 81°16' 13·152 | 77°0' 13·341 | 72°54' 13·601 | 68°58' 13·928 | 65°13' 14·317 | 61°42' 14·764 | 58°24' 15·264 | 55°18' 15·811 | 52°26' 16·401 |
| 14 | 85°55' 14·035 | 81°53' 14·142 | 77°54' 14·317 | 74°4' 14·560 | 70°21' 14·866 | 66°48' 15·231 | 63°27' 15·652 | 60°16' 16·124 | 57°16' 16·643 | 54°28' 17·204 |
| 15 | 86°12' 15·032 | 82°25' 15·132 | 78°42' 15·297 | 75°5' 15·524 | 71°34' 15·811 | 68°12' 16·155 | 64°59' 16·552 | 61°56' 17·000 | 59°2' 17·492 | 56°19' 18·027 |
| 16 | 86°26' 16·031 | 82°53' 16·124 | 79°23' 16·278 | 75°58' 16·492 | 72°39' 16·763 | 69°26' 17·088 | 66°22' 17·464 | 63°27' 17·888 | 60°38' 18·357 | 59°0' 18·968 |
| 17 | 86°39' 17·029 | 83°18' 17·117 | 79°59' 17·262 | 76°46' 17·464 | 73°37' 17·720 | 70°33' 18·027 | 67°37' 18·384 | 64°48' 18·788 | 62°6' 19·235 | 59°33' 19·723 |
| 18 | 86°50' 18·027 | 83°40' 18·110 | 80°33' 18·248 | 77°29' 18·439 | 74°29' 18·681 | 71°34' 18·973 | 68°45' 19·313 | 66°3' 19·697 | 63°27' 20·124 | 60°57' 20·591 |
| 19 | 87°0' 19·026 | 84°0' 19·105 | 81°2' 19·235 | 78°7' 19·416 | 75°16' 19·646 | 72°28' 19·924 | 69°46' 20·248 | 67°10' 20·615 | 64°39' 21·023 | 62°15' 21·470 |
| 20 | 87°9' 20·025 | 84°18' 20·099 | 81°28' 20·223 | 78°42' 20·396 | 75°58' 20·615 | 73°18' 20·880 | 70°43' 21·189 | 68°12' 21·540 | 65°46' 21·931 | 63°27' 22·360 |

123. What is the price asked, and the terms of payment?

124. Say distinctly whether you recommend the property on these terms or not.

125. If not, state any conditions or reservations with which you recommend it.

## Z. Finally—

126. State anything else you think will be of use or interest in connection with the property.

# ELEMENTARY GEOLOGY FOR MINERS.

Some knowledge of geology is essential to the practical miner, and desirable in the investor. The most elementary acquaintance with the subject, for instance, would have prevented the expenditure of money in boring in granite for coal-beds.

Gold-bearing reefs are found principally in metamorphic rocks, and amongst dykes which have dislocated and disturbed the strata. Heated waters carrying minerals in solution and circulating in fractures in the earth's crust have played an important part in the formation of reefs and the alteration of rocks. Some knowledge, therefore, of earth-movements is very necessary.

The following outline will, it is hoped, be serviceable, and lead to further study of this science.

## SEDIMENTARY ROCKS.

CLAY, deposited by water, becomes compressed into MUDSTONE. Under the influences of greater pressure and heat it becomes SHALE or SLATE. SANDSTONE is composed of coarser stuff (sand) deposited by water. GREYWACKE is a greyish, compact, granular, very tough, fine-grained sandstone, hard to bore.

Under the influence of heat and pressure sandstone becomes QUARTZITE, which is hard, and has a characteristic lustre or sheen. Quartzite is also formed from slate and some other rocks by the infiltration of silica (quartz) in solution, which alters and hardens the rock. SCHIST is formed from slate, sandstone, and other rocks, both sedimentary and igneous, by further heat and pressure. It occasionally shows a wavy structure. GNEISS is formed by the still further alteration of rocks by great heat and pressure. In appearance it is very like granite, and is composed of the same materials.

Rocks altered by heat, pressure, and aqueous solutions of minerals are called Metamorphic.

CONGLOMERATE is formed from coarser materials than sandstone, such as gravel and shingle. BRECCIA is sharp, angular fragments cemented together, not waterworn as in the case of conglomerate.

All of the above are formed from the wearing away of older rocks by natural agencies. When granite, for instance, is worn away, the quartz grains are deposited by water and become sandstone, while the felspar and mica are carried further and form the clay which becomes slate, etc.

Felspar is essentially a silicate of alumina, with variable proportions of silicates of potash, soda, magnesia, and lime. Clay is principally composed of felspar, generally containing more or less sand. KAOLIN is a purer form of clay (felspar).

Slate and sandstone are generally deposited in alternate layers, called beds or strata (see fig. 1), sometimes shading off into slaty sandstones or sandy slates. The bedding planes are the divisions between the various layers. Under the influence of pressure another series—cleavage planes—is developed, which may quite obliterate the bedding planes. The cleavage planes may coincide with the bedding planes, or be at any angle to them (see fig. 8). Slates split along the bedding planes if unaltered, and along the cleavage planes when the latter are well developed.

Sedimentary rocks, which were originally laid down nearly flat, become tilted at all angles, and fractured and bent into great folds, by pressure due to movements in the earth's crust (see fig. 2). Eruptive (molten) rocks are forced into them (dykes, bosses, etc.), and the great alterations to schist, gneiss, etc., are produced. The arches in these folded rocks are termed *anticlines*, the troughs are *synclines*. In the anticlines the celebrated Bendigo saddle reefs are formed ($x$, $y$, fig. 2).

When sedimentary rocks are tilted on edge, a horizontal line along the bedding planes is called the STRIKE; while the inclination at which they lie from the horizontal, in a direction at right angles to the strike, is the DIP or UNDERLIE.

FAULTS, the cracks formed in rocks, are of great importance to the miner, for in them lodes may be formed; and the movements caused by these cracks frequently displace the lodes. Fault cracks are sometimes filled with dyke material.

When a fault runs with the strike of the rocks it is a *strike fault*, or *slide* ($a$, fig. 3); when it runs across the strike it is a dip fault or cross-course ($k$, $k$, fig. 4). Faults may coincide with the bedding planes in dip, or cross them at any angle.

When faults fracture the rocks, movements have generally taken place; the rocks on the hanging wall more often sinking down. A lateral or side movement may also occur. The up or down displacement is the *throw* of the fault, the side movement is the *heave*.

The strike and dip of a reef are named in the same manner as those of the strata. The direction of a horizontal drive on a reef is its *strike*, and the *dip* or *underlie* is the inclination from the horizontal, at right angles to the strike. The inclination of an ore-body or *shoot* from the horizontal, in the direction of the strike of the reef, is its *pitch* (see *x, x*, fig. 5).

## ERUPTIVE ROCKS.

For our present purpose these may be divided into those which have been forced into, and remain in, the sedimentary rocks; and those which have reached the surface and flowed over the land.

The first series form (1) large *bosses* of granitic rocks which disturb and alter the slates, etc., over great areas (*a*, fig. 7); and (2) *dykes* which run in cracks through the slates, etc., displacing the rocks to a less extent, and only altering their character near the dykes (*k, k*, fig. 4).

The second series flow from volcanic vents and dyke cracks, over the country, filling and burying rivers, valleys, etc., and roughly levelling the surface (*e, g*, fig. 7). It is in this manner that the *deep-leads* were buried.

Granite, which is composed of quartz, felspar, and mica, is a type of the rocks which form bosses; Diorite, composed of felspar and hornblende, is a typical dyke rock; and Basalt, consisting principally of felspar and augite, typifies the rocks which flow over the surface.

## ORGANICALLY FORMED ROCKS.

*Limestone, Marl*, etc., are formed from the remains of shells, coral, etc., and *Coal* from the compression of buried forests. Rock salt, gypsum, etc., have been deposited in inland lakes.

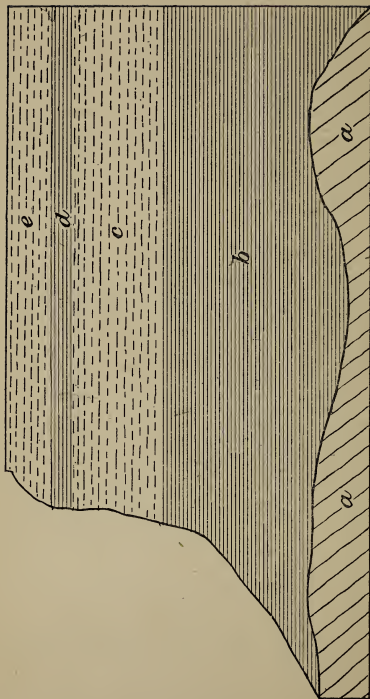The following diagrams illustrate the above remarks :—

Fig. 1.—Longitudinal Section.

43

### Fig. 1.

Old rocks, *a*, have been worn away irregularly. Afterwards water has laid down, on top of the old rocks, mud and sand, which have been compressed into slate, *b, d*, and sandstone, *c, e*. After the deposition of the first and thick layer of slate, *b*, two layers of sandstone, *c, e*, with a layer of slate, *d*, between, have been deposited.

The slate, *b*, is said to rest *unconformably* on the older strata.

RIGHT RUNNING LODES.—Main lodes of district. CROSS-COURSES.—Lodes running at right angles to the main lodes. CAUNTER-LODES.—Lodes running in any other direction.*

DIRECTION OF HEAVES.—In the majority of cases, where a lode is intersected by a fault, the lode is heaved in the direction of the greater angle.

CONTACT DEPOSITS consist of accumulations of mineral along lines of junction of two dissimilar rocks, which are sometimes of very different ages.

* For this and a few other notes I am indebted to *Prospecting for Minerals*, by S. H. Cox, published by C. Griffin & Co., Ltd., a book that should be in the hands of every miner and mining investor.
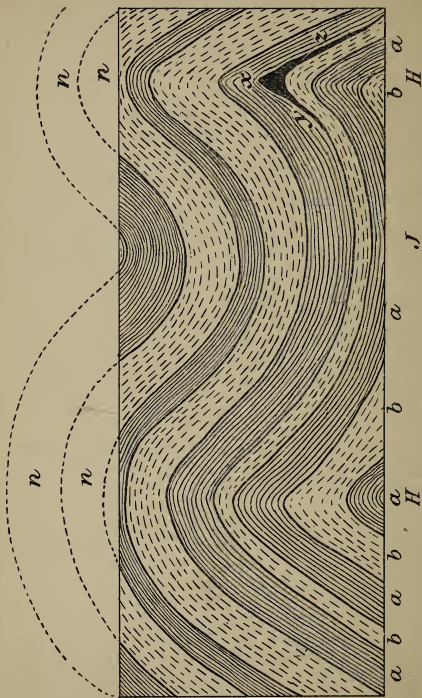
Fig. 2.—Transverse Section.

45

FIG. 2.

Alternate layers of slate, $a$, and sandstone, $b$, originally laid down horizontally as in fig. 1, have been subsequently compressed and folded as shown in fig. 2. The arches at $H$, $H$ are *anticlines*, the trough at $J$ is a *syncline*.

In the anticline $H$ a saddle reef has been formed; $x$ is the cap and $y$, $z$ are the legs of the saddle reef.

The beds of slate and sandstone formerly continued as at $n$, $n$, but the upper portions have been denuded. When the country is bent into long folds the curvature is not noticeable in short sections, such as that shown in fig. 3.

Before investing in undeveloped claims because they are near a prosperous mine, it is well to inquire, amongst other things, whether the lode runs and lives in the direction of the claim in question. Attention to this apparently obvious point would have saved many people serious loss.

The miner has always to be careful not to deceive himself, and not to be led to conclusions which he desires to form, if they are not supported by facts; and this is perhaps the most difficult lesson of all which he has to learn.

Whereas twenty years ago less than $\frac{1}{2}$ oz. per ton was not considered payable at 2500 feet, now at 4500 feet 5 dwts. of gold per ton can be made to pay.—*Official Report on Bendigo, Australia.*
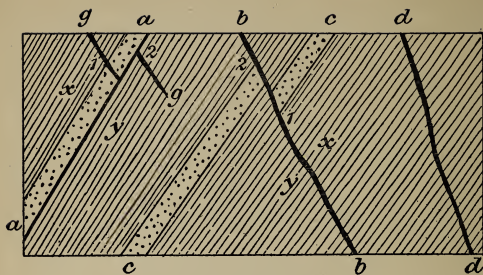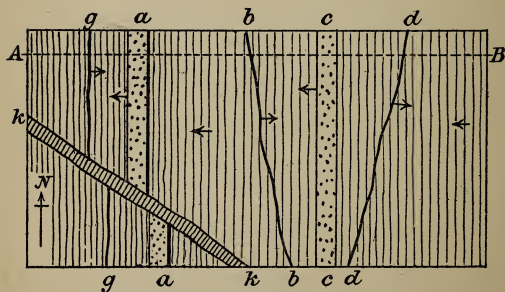
Fig. 3.—Cross Section.



Fig. 4.—Plan.

47

## Fig. 3.

This figure shows a cross section of a thick belt of slate forming part of the west side of a large anticline, and containing small belts of sandstone, *a, a, c, c.* On the lower side of the sandstone *a, a* is a slide—that is, a crack where the rock has moved on the junction plane. The movement is shown by the displacement of the small reef *g, g.* *b, b, d, d* are cracks or faults crossing and fracturing the bedding planes at high angles. When these cracks are filled with lode material, a fissure lode or reef results; when filled with molten, or heated plastic, rock material, a dyke is formed.

The hanging wall *x* of the fault *a, a* has slipped down on the foot-wall *y,* displacing the leader *g, g* from 2 to 1. The bed of sandstone *c, c,* which is faulted by the lode *b, b,* is also thrown down from 2 to 1. The dip or underlie of *b* or *d* is the angle it makes with the horizontal.

*b* underlies at about 60 degrees east, *d* underlies at about 70 degrees east.

## Fig. 4.

This is a view in plan of the country shown in fig. 3. The cross section, fig. 3, is taken on the line *AB* in fig. 4.
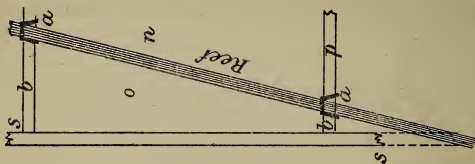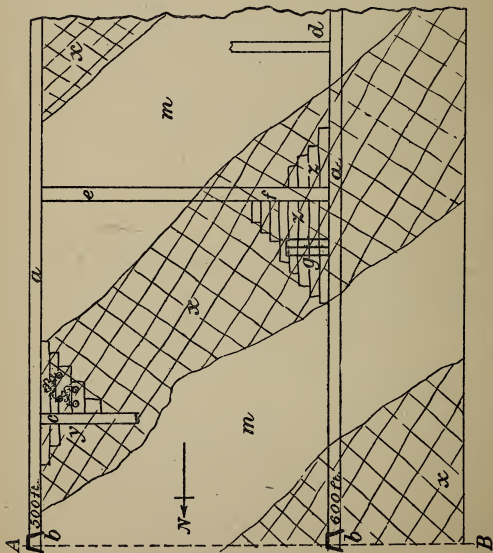
The strike of a lode or stratum is the direction of a horizontal line along its course. The lode *b, b* strikes about 10 degrees west. The lode *d, d* strikes about 10 degrees east. The country strikes north. The beds of sandstone *a, a, c, c* of course coincide with the strike of the slate with which they are interbedded. The strike of the slide *a, a* also agrees with that of the strata.

The small arrow-heads indicate the direction of dip of the lodes and strata.

A dyke, or cross-course, *k, k,* has faulted the country after the reef or leader *g, g* was formed. This is shown by the reef and the beds of slate and sandstone all being heaved the same distance to the west by the dyke.

The dyke *k, k* is a fault-fissure which has been filled with molten rock—basalt or diorite, etc.

The dyke does not show in fig. 3, for it is south of the point where the cross section is taken.

FIG. 5.
Longitudinal Section.



FIG. 6.
Cross Section.

49

### FIGS. 5 and 6.

Fig. 5 is a longitudinal section along a reef, looking east.
Fig. 6 is a cross section on *AB* in fig. 5, looking north.

*s, s* is the shaft, which will be cut the reef when sunk a few feet further. *o* is the hanging wall of the reef, *n* the foot-wall. *b, b* are *crosscuts* from the shaft, intersecting the reef at 500 feet and 600 feet. At *p* the crosscut has been continued for prospecting purposes. *a, a* are two *drives* or *levels* driven on the course of the reef. *c* is a *winze* sunk from the 500-feet level; *d* is a *rise* put up from the 600-feet level. *e, f* show a winze and rise which have met, or *holed through*, forming a way from one level to the other. The rises and winzes follow the course of the lode from one level to another. *z, z* are *overhead stopes* above the 600-feet level, starting from the rise *f*. *g* is a *pass*, "chute," which is being carried up through the stopes, so that stone and mullock may be sent down to trucks in the level below. The worked-out ground is generally filled with waste rock as the work progresses, both to support the walls and to avoid hauling the rock. *x, x, x* are *shoots* of ore *pitching* south at about 50 degrees. Between the shoots, at *m, m*, the reef is either pinched out or not of payable grade.

*y* shows *underhand stopes* from the winze *c*. The waste rock is *stowed* on timber as far as possible.

Though in some districts particular meanings are attached to the terms REEF, VEIN, and LODE, they are generally used indiscriminately.

SHOOT, CHUTE.—There is much diversity of opinion as to the use of these two words, but it seems desirable to use *shoot* for an ore body, and *chute* for an ore pass.
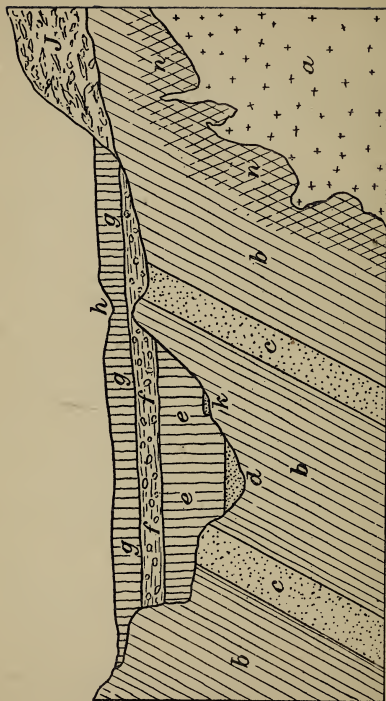
FIG. 7.—Cross Section

51

### FIG. 7.

*a* is a granite boss which has been forced into sedimentary beds of slate, *b*, *b*, and sandstone, *c*, *c*, breaking them from the horizontal, and forming an anticline, of which only the left side is shown. The slates and sandstones *n*, *n*, near the boss will be considerably altered by heat, aqueous solutions, and pressure. On the denuded edges of the slate and sandstone an old river-bed is shown, containing auriferous gravel, *d*. The valley has been filled by a flow of basalt, *e*, over which sand and gravel, *f*, have been deposited, and covered by another flow of basalt, *g*. The present stream flows at *h*. *J* is the remains of a deposit which once extended across the valley, but has nearly all been removed by the old river. Some auriferous wash deposited at *k* is on an old raised beach or terrace.

WORKING EXPENSES.—When working a large low-grade deposit, the whole success depends on a most careful attention to detail. On an output of 1000 tons a day, a halfpenny represents over £600 a year.

ALLUVIAL DEPOSITS.—Under most favourable conditions, as low returns as 2½d. per cubic yard can be made to pay handsomely by hydraulic sluicing.
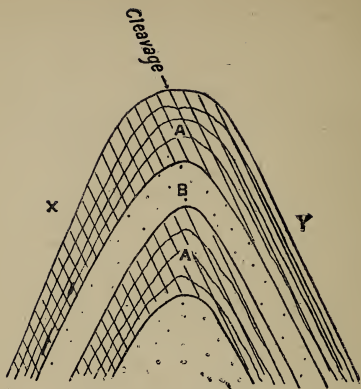
FIG. 8.

Fig. 8 shows an anticline in which the bedding planes of the slate, *A*, *A*, and sandstone, *B*, are parallel to the arches; the strata having been originally deposited horizontally, but subsequently curved by pressure into the arch. Cleavage planes have been developed by the pressure; they vary from a direction almost at right angles to the bedding planes, as at *X*, to one nearly parallel to them at *Y*.

When a true lode appears to pinch out, it will inevitably widen again lower down; and when it is cut off by a slide, it may be found again heaved to the right or left. What the miner has to decide is whether it is worth his while to spend the time and money necessary to recover a lode that has been lost.

## THE GEOLOGICAL RECORD

### (Geikie).

| | |
|---|---|
| **Post-Tertiary** or **Quaternary.** | Recent and Prehistoric. Pleistocene or Glacial. |
| **Cainozoic** or **Tertiary.** | Pliocene. Miocene. Oligocene. Eocene. |
| **Mesozoic** or **Secondary.** | Cretaceous. Jurassic. Triassic. |
| **Palæozoic** or **Primary.** | Permian. Carboniferous Devonian and Old Red Sandstone. Silurian. Cambrian. |
| **Pre-Cambrian.** | Archæan. |

## MINERALS FREQUENTLY ASSOCIATED WITH GOLD.

| Mineral. | Colour. | Streak. | Hardness. | Remarks. |
|---|---|---|---|---|
| PYRITES, $FeS_2$ | Bronze-yellow or pale brass-yellow. | Greenish or brownish black. | 6·6·5 | Sulphide of iron. |
| MARCASITE, $FeS_2$ | Paler than pyrites. | | | Do. Decomposes more readily. |
| PYRRHOTINE, Magnetic Pyrites, $Fe_6S_7$ | Reddish or brownish, bronze or copper colour. | Dark-greyish to black. | 3·5-4·5 | Sulphide of iron. |
| MISPICKEL, Arsenopyrite, $FeS_2 + FeAs_2$ | Tin-white or silver-white to steel-grey. | Dark-greyish to black. | 5·5-6 | Bisulphide and arsenide of iron. Tarnishes pale copper-coloured on exposure. |
| COPPER PYRITES, Chalcopyrite, $CuFeS_2$ | Brass-yellow. | Greenish black. | 3·5-4 | Sulphide of copper and iron. Tarnish iridescent (peacock copper). |
| BOURNONITE, Cu, Pb, Sb, and S | Steel-grey or lead-grey, sometimes blackish. | Same as colour. | 2·5-3 | Sulphide of copper, lead, and antimony. |
| ZINC BLENDE, Black Jack, ZnS | Black or brown, sometimes yellow, rarely colourless. | White to reddish brown. | 3·5-4 | Sulphide of zinc. Iron usually present. |
| GALENA, PbS | Lead-grey, opaque. | Same as colour. | 2·5-2·7 | Sulphide of lead. |

| Mineral | Colour | Streak | Hardness | Composition |
|---|---|---|---|---|
| STIBNITE, Antimonite, $Sb_2S_3$ | Lead-grey. | Lead-grey. | 2 | Sulphide of antimony. Liable to tarnish. |
| NATIVE TELLURIUM, Te | Tin-white. | Tin-white. | 2–2·5 | Contains a little gold and iron. |
| GRAPHIC TELLURIUM Sylvanite, $AgTe_4 + AuTe_3$ BLACK TELLURIUM, Nagyagite | Steel-grey to silver-white, sometimes yellowish. Dark lead-grey. | Same as colour. Do. | 1·5–2 | Telluride of gold and silver. Telluride and sulphide of lead and gold. |
| CINNABAR, HgS | Cochineal red, brownish or dark-coloured. | Scarlet. | 2–2·5 | Sulphide of mercury. |
| BARYTES, Heavy Spar, $BaSO_4$ | Colourless or white, often tinted. | White. | 2·5–3·5 | Sulphate of baryta. |
| FLUOR SPAR, $CaF_2$ | White, green, purple, etc. | White. | 4 | Fluoride of calcium (lime). |
| CALCITE, Calc Spar, $CaCO_3$ | White, but often tinted. | White or greyish. | 2·5–3·5 | Carbonate of lime. |
| APATITE, $3(Ca_3P_2O_8) + CaCl_2$ or $+ CaF_2$ | Pale sea-green, or many other tints. | White. | 4·5–5 | Phosphate of lime, with fluoride or chloride of lime, or both. |

"The science (Geology) may be divided into Theoretical Geology, which investigates the origin and structure of the rocky crust of the earth ; and Economic or Mining Geology, which bears more directly on mining. . . . What anatomy is to the modern surgeon, so is geology to the mining profession."—J. PARK.*

———————

"The character of the rock or country exerts a very great influence on the behaviour of lodes and on the distribution of the rich parts ; this has been proved, beyond doubt, to be the case in every district which has been carefully studied."
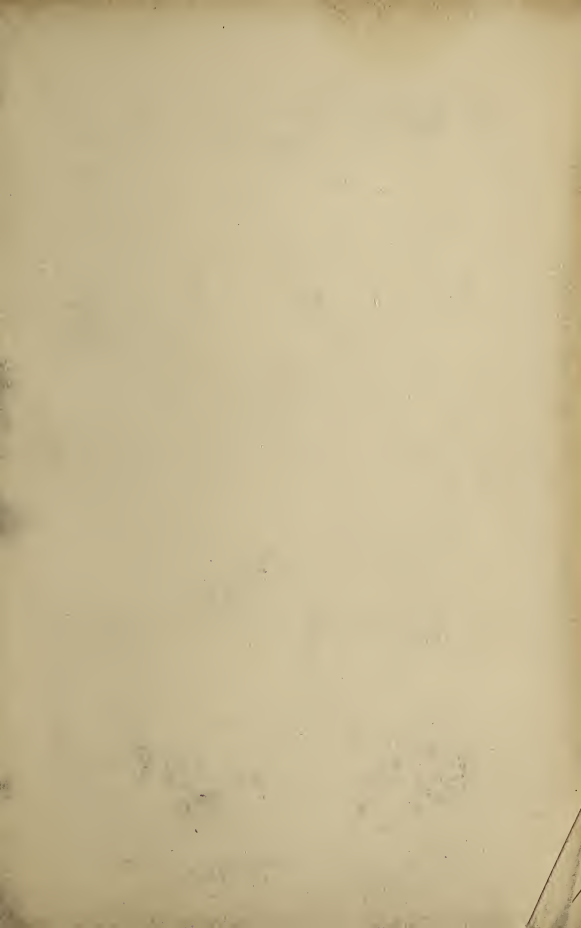
———————

"Directors should be honest, and should possess business abilities. It does not much matter whether they are experienced or not in mining. The technical experience is, or ought to be, supplied to them."—J. H. COLLINS.
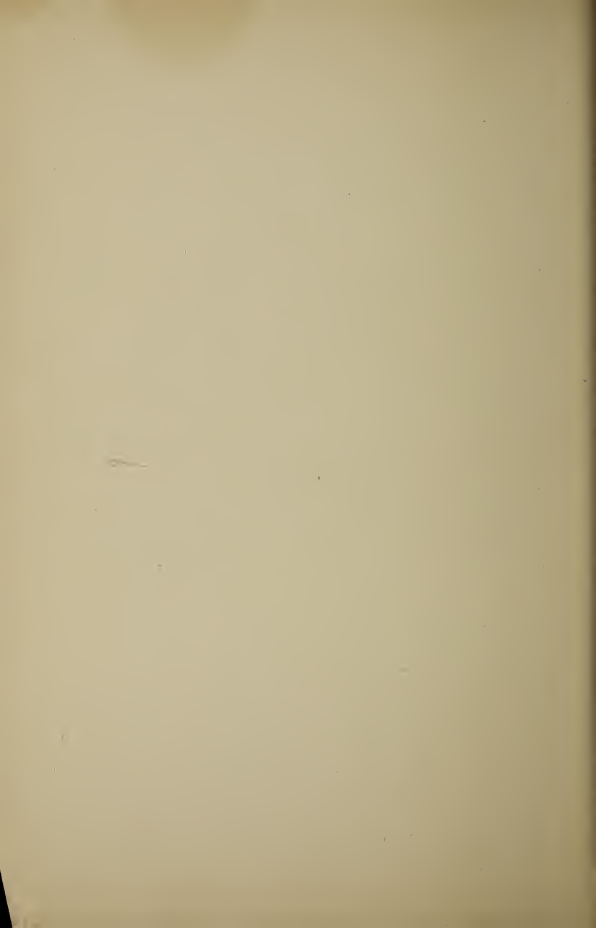
———————

When a mine is found which furnishes satisfactory answers to all the questions, the mining millennium will have arrived. The concern of the mining engineer, after ascertaining his facts, is to weigh the advantages and disadvantages of the proposition before him, and to decide whether the advantages preponderate to a sufficient degree to warrant the purchase.
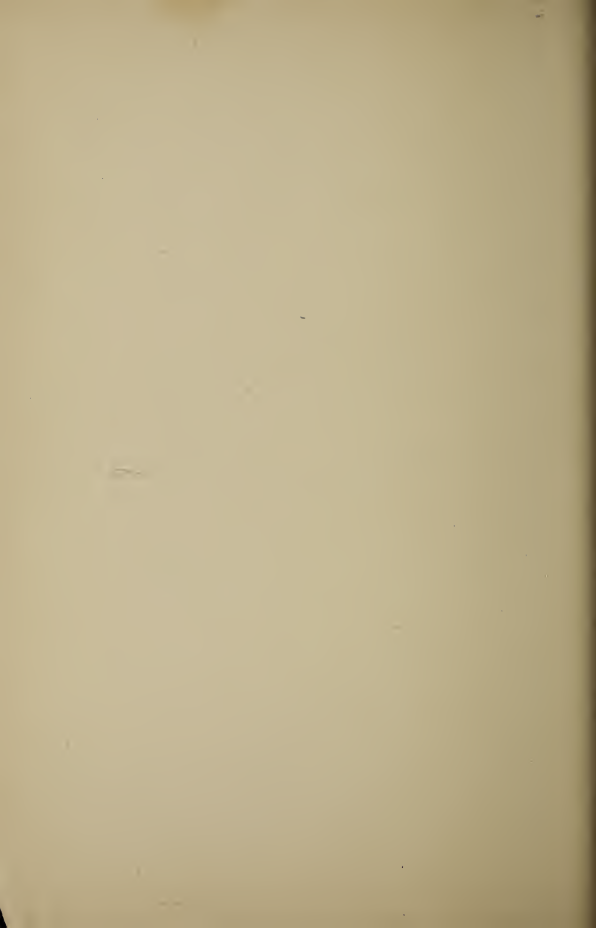
* *A Text-book of Mining Geology*, Griffin & Co., Ltd.